to the nerves and the bones, we have gone beyond the subject I proposed to speak upon. My subject belongs to physical science ;—what is called in Scotland, Natural Philosophy. Physical science refers to dead matter, and I have gone beyond the range whenever I speak of a living body ; but we must speak of a living body in dealing with the senses as the means of perceiving—as the means by which, in John Bunyan's language, the soul in its citadel acquires a knowledge of external matter. The physicist has to think of the organs of sense, merely as he thinks of the microscope ; he has nothing to do with physiology. He has a great deal to do with his own eyes and hands, however, and must think of them, if he would understand what he is doing, and wishes to get a reasonable view of the subject, whatever it may be, which is before him in his own department.

Now what is the external object of this internal action of hearing and perceiving sound ? The external object is a change of pressure of air. Well, how are we to define a sound simply ? It looks a little like a vicious circle, but indeed it is not so, to say it is sound if we call it a sound—if we perceive it as sound, it *is* sound. Any change of pressure, which is so sudden as to let us perceive it as sound is a sound. There [giving a sudden clap of the hands]—that is a sound. There is no question about it—nobody will ever ask, Is it a sound or not ? It is sound if you hear it. If you do not hear it, it is not to you a sound. That is all I can say to define sound. To explain what it is, I can say, it is change of pressure, and it differs from a gradual change of pressure as seen on the barometer only in being more rapid, so rapid that we perceive it as a sound. If you could perceive by the ear, that the barometer has fallen two-tenths of an inch to-day, that would be sound. But nobody hears by his ear that the barometer has fallen, and so he does not perceive the fall as a sound. But the same difference of pressure coming on us suddenly—a fall of the barometer, if by any means it could happen, amounting to a tenth of an inch, and taking place in a thousandth of a second,—would affect us quite like sound. A sudden rise of the barometer would produce a sound analogous to what happened when I clapped my hands. What is the difference between a noise and a musical sound ? Musical sound is a regular and periodic change of pressure. It is an alternate augmentation and diminution of air pressure, occurring rapidly enough to be perceived as a sound, and taking place with perfect regularity, period after period. Noises and musical sounds merge into one another. Musical sounds have a possibility at least of sometimes ending in a noise, or tending too much to a noise, to altogether please a fastidious musical ear. All roughness, irregularity, want of regular, smooth periodicity, has the effect of playing out of tune, or of music that is so complicated that it is impossible to say whether it is in tune or not.

But now, with reference to this sense of sound, there is something I should like to say as to the practical lesson to be drawn from the great mathematical treatises which were placed before the British Association, in the addresses of its president, Prof. Cayley, and of the president of the mathematical and physical section, Prof. Henrici. Both of these professors dwelt on the importance of graphical illustration, and one graphical illustration of Prof. Cayley's address may be adduced in respect of this very quality of sound. In the language of mathematics we have just "one independent variable" to deal with in sound, and that is air pressure. We have not a complication of motions in various directions. We have not the complication that we shall have to think of presently, in connection with the sense of force ; complication as to the place of application, and the direction, of the force. We have not the infinite complications we have in some of the other senses, notably smell and taste. We have distinctly only one thing to consider, and that is air pressure or the variation of air pressure. Now when we have one thing that varies, that, in the language of mathematics, is "one independent variable." Do not imagine that mathematics is harsh, and crabbed, and repulsive to common sense. It is merely the etherealisation of common sense. The function of one independent variable that you have here to deal with is the pressure of air on the tympanum. Well now in a thousand counting houses and business offices in Birmingham and London, and Glasgow, and Manchester, a curve, as Prof. Cayley pointed out, is regularly used to show to the eye a function of one independent variable. The function of one independent variable most important in Liverpool perhaps may be the price of cotton. A curve showing the price of cotton, rising when the price of cotton is high, and sinking when the price of cotton is low, shows all the complicated changes of that independent variable

to the eye. And so in the Registrar-General's tables of mortality, we have curves showing the number of deaths from day to day—the painful history of an epidemic, shown in a rising branch, and the long gradual talus in a falling branch of the curve, when the epidemic is overcome, and the normal state of health is again approached. All that is shown to the eye ; and one of the most beautiful results of mathematics is the means of showing to the eye the law of variation, however complicated, of one independendent variable. But now for what really to me seems a marvel of marvels : think what a complicated thing is the result of an orchestra playing—a hundred instruments and two hundred voices singing in chorus accompanied by the orchestra. Think of the condition of the air, how it is lacerated sometimes in a complicated effect. Think of the smooth gradual increase and diminution of pressure—smooth and gradual, though taking place several hundred times in a second—when a piece of beautiful harmony is heard ! Whether, however, it be the single note of the most delicate sound of a flute, or the purest piece of harmony of two voices singing perfectly in tune ; or whether it be the crash of an orchestra, and the high notes, sometimes even screechings and tearings of the air, which you may hear fluttering above the sound of the chorus—think of all that, and yet that is not too complicated to be represented by Prof. Cayley, with a piece of chalk in his hand, drawing on the blackboard a single line. A single curve, drawn in the manner of the curve of prices of cotton, describes all that the ear can possibly hear, as the result of the most complicated musical performance. How is one sound more complicated than another ? It is simply that in the complicated sound the variations of our one independent variable, pressure of air, are more abrupt, more sudden, less smooth, and less distinctly periodic, than they are in the softer, and purer, and simpler sound. But the superposition of the different effects is really a marvel of marvels ; and to think that all the different effects of all the different instruments can be so represented ! Think of it in this way. I suppose everybody present knows what a musical score is—you know, at all events, what the notes of a hymn tune look like, and can understand the like for a chorus of voices, and accompanying orchestra—a "score" of a whole page with a line for each instrument, and with perhaps four different lines for four voice parts. Think of how much you have to put down on a page of manuscript or print, to show what the different performers are to do. Think, too, how much more there is to be done than anything the composer can put on the page. Think of the expression which each player is able to give, and of the difference between a great player on the violin and a person who simply grinds successfully through his part ; think, too, of the difference in singing, and of all the expression put into a note or a sequence of notes in singing that cannot be written down. There is, on the written or printed page, a little wedge showing a diminuendo, and a wedge turned the other way showing a crescendo, and that is all that the musician can put on paper to mark the difference of expression which is to be given. Well now, all that can be represented by a whole page or two pages of orchestral score, as the specification of the sound to be produced in say ten seconds of time, is shown to the eye with perfect clearness by a single curve on a riband of paper a hundred inches long. That to my mind is a wonderful proof of the potency of mathematics. Do not let any student in this Institute be deterred for a moment from the pursuit of mathematical studies by thinking that the great mathematicians get into the realm of four dimensions, where you cannot follow them. Take what Prof. Cayley himself, in his admirable address, which I have already referred to, told us of the beautiful and splendid power of mathematics for etherealising and illustrating common sense, and you need not be disheartened in your study of mathematics, but may rather be reinvigorated when you think of the power which mathematicians, devoting their whole lives to the study of mathematics, have succeeded in giving to that marvellous science.

(*To be continued.*)

THE GEOLOGICAL POSITION OF THE HUMAN SKELETON FOUND AT TILBURY

IN a paper on this subject read by Mr. T. V. Holmes, F.G.S., at the meeting of the Essex Field Club on Saturday, February 23, at Buckhurst Hill, the author pointed out that the Tilbury skeleton was found in recent alluvium. The section at

Tilbury, consisting of blue clay with peaty bands, above sand and gravel, strongly resembles those given by Prof. Sollas of the alluvial deposits of the estuary of the Severn ; the amount of subsidence, as shown by the present position of the lower peaty band, being also nearly the same. Mr. Holmes considered the notions promulgated in the brief newspaper reports regarding the antiquity of the remains to be entirely misleading. If any strata were entitled to be styled "recent," those at Tilbury must be so ; for their deposition would now be going on but for the embankment of the Thames during the Roman occupation of Britain. Yet the newspaper reports described these beds by the extremely vague term "Pleistocene," while the skeleton was styled "Palæolithic." The remains of man, however, have been found in alluvial deposits fifty feet above the present level of the Thames, and remains found in such beds must be immensely more ancient than any discovered in recent alluvium. Geological position furnishes the only absolute test of relative age. The test of association with extinct mammalia is largely dependent on negative evidence. A hint on this point was given by the results of the drainage of Haarlem Lake thirty years ago. Excellent sections were made in all directions across its bed, and carefully examined by skilled geologists. Hundreds of men were known to have perished in its waters three centuries before, and it had always been the centre of a considerable population. Yet no human bones were found, though works of art were. Thus hundreds or even thousands of mammalia, incapable of producing works of art, might be interred in particular strata, and yet leave no signs whatever of their former existence two or three centuries afterwards. And, on the other hand, were extinct mammalia present in the Tilbury Dock beds no additional antiquity would thereby be conferred on the beds themselves, but the period at which the animals became extinct would be shown to be later than had been supposed. Similarly as regards the rude implements known as Palæolithic ; their presence could confer no antiquity on recent beds. Still, as the skeleton was found thirty-two feet below the surface, in alluvium that has received no additions since Roman times, it is unquestionably prehistoric. And the extreme rarity of prehistoric human skeletons gives to this discovery an interest greater than could have been claimed for that of a bushel of flint implements. The age of the Tilbury skeleton may possibly be not far removed from that of the Neanderthal man, to which it is said to have a strong resemblance : a resemblance which, if as great as it is stated to be, goes far to show that we have in each a normal type of prehistoric man.

At the same meeting a communication from Mr. Worthington G. Smith was read. Mr. Smith stated that he had seen the skeleton, and specimens of the sand in which it was found. Palæolithic sands with fossil bones and stone implements occur about a mile to the north of Tilbury, and with these Mr. Smith was well acquainted. The Palæolithic sand is quite different in colour from the Tilbury sand, and the former swarms with fossil shells of land and freshwater mollusks. As far as could be seen no such shells were present in the Tilbury sand sent to the British Museum. Mr. Smith's specimens of fossil bones from the Palæolithic sand were in an entirely different mineral condition from the bones of the Tilbury skeleton, and he could trace no resemblance whatever either in sand or bones. Mr. Smith made this statement with great deference to the opinion of Sir Richard Owen, and confessed that a Palæolithic skeleton might have been washed from the high ground to the low, and got into the mineral state of the Tilbury skeleton, although at present there was no evidence of anything of the sort having taken place. His opinion was that there was no proof of the Palæolithic age of the Tilbury relic.

NOTES ON THE VOLCANIC ERUPTION OF MOUNT ST. AUGUSTIN, ALASKA, OCTOBER 6, 1883 [1]

ON the western side of the entrance to Cook's Inlet (forty-five miles wide) lies Cape Douglas ; and to the northward of the cape the shore recedes over twenty miles, forming the Bay of Kamishak. In the northern part of this bay lies the Island of Chernaboura ("black-brown"), otherwise called Augustin Island. It is eight or nine miles in diameter, and near its north-eastern part rises to a peak, called by Cook Mount St. Augustin. As laid down by Tebenkoff, the island is nearly round.

[1] From *Science*.

The northern shores are high, rocky, and forbidding, and are bordered by vast numbers of rocks and hidden dangers. The southern shore is comparatively low.

Mount St. Augustin was discovered and named by Capt. Cook, May 26, 1778; and he describes it as having "a conical figure, and of very considerable height." In 1794 Puget describes it as—

"A very remarkable mountain, rising with a uniform ascent from the shores to its lofty summit, which is nearly perpendicular to the centre of the island, inclining somewhat to its eastern side. . . . Towards the seaside it is very low, from whence it rises, though regular, with a rather steep ascent, and forms a lofty, uniform, and conical mountain, presenting nearly the same appearance from every point of view, and clothed with snow and ice, through which neither tree nor shrub were seen to protrude ; so that, if it did produce any, they must either have been very small, or the snow must have been sufficiently deep to have concealed them."

At that time there were native hunters, under the direction of two Russians, hunting or living in the vicinity of the north-eastern point of the island.

Vancouver placed the peak of this mountain in latitude 59° 22'; Tebenkoff places it in latitude 59° 24'.

The peak of St. Augustin is distant forty-nine miles nearly due west (true) from the settlement on the southern point of Port Graham, or, as it is sometimes called, English Harbour. This harbour is situated on the eastern side of Cook's Inlet, near Cape Elizabeth.

In connection with the fall of pumice-dust at Iliuliuk on October 16, 1883, it may be of interest to observe that the peak of Augustin is over 700 miles to the north-eastward of Bogosloft Island off Unalashka.

About eight o'clock on the morning of October 6, 1883, the weather being beautifully clear, the wind light from the south-westward (compass), and the tide at dead low water, the settlers and fishing parties at English Harbour heard a heavy report to windward (Augustin bearing south-west by west three-fourths west by compass). So clear was the atmosphere that the opposite or north-western coast of the inlet was in clear view at a distance of more than sixty miles.

When the heavy explosion was heard, vast and dense volumes of smoke were seen rolling out of the summit of St. Augustin, and moving to the north-eastward (or up the inlet) under the influence of the lower stratum of wind ; and, at the same time (according to the statements of a hunting-party of natives in Kamishak Bay), a column of white vapour arose from the sea near the island, slowly ascending, and gradually blending with the clouds. The sea was also greatly agitated and boiling, making it impossible for boats to land upon or to leave the island.

From English Harbour (Port Graham) it was noticed that the columns of smoke, as they gradually rose, spread over the visible heavens, and obscured the sky, doubtless under the influence of a higher current (probably north or north-east). Fine pumice-dust soon began to fall, but gently, some of it being very fine, and some very soft, without grit.

At about 8.25 a.m., or twenty-five minutes after the great eruption, a great "earthquake-wave," estimated as from twenty-five to thirty feet high, came upon Port Graham like a wall of water. It carried off all the fishing-boats from the point, and deluged the houses. This was followed at intervals of about five minutes, by two other large waves, estimated at eighteen and fifteen feet ; and during the day several large and irregular waves came into the harbour. The first wave took all the boats into the harbour, the receding wave swept them back again to the inlet, and they were finally stranded. Fortunately it was low water, or all of the people at the settlement must inevitably have been lost. The tides rise and fall about fourteen feet.

These earthquake-waves were felt at Kadiak, and are doubtless recorded on the register of the Coast Survey tide-gauge at that place. Also the pumice-ashes fell to the depth of four or five inches, and a specimen of the deposit was given to the tidal observer at St. Paul. It will be interesting to compare these ashes with those collected at Iliuliuk on October 16, and which, from a confusion of dates, were supposed to have come from the new Bogosloff volcanic island. I am of the opinion that they came from St. Augustin.

The condition of the Island of Augustin or Chernaboura, according to the latest accounts, is this :—

At night, from a distance of fifty or sixty miles, flames can be